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Cost-Effectiveness Analysis - Restoration measures, the Polskava River

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Abstract

Implementation of the EU Directive 2000/60/EC (Water Framework Directive, hereinafter called WFD) and its environmental objectives is based on cyclic stepwise planning approach. The technical analysis, i.e. characterization of the river basin district, review of the environmental impact of human activity, first economic analysis and publishing of significant water management issues, are already carried out and form the starting point for setting the programme of measures as the focal point of River Basin Management Plans.

The programme of measures comprises basic and supplementary measures. The supplementary measures are, according to the provisions of the WFD, subject of economic analysis: cost-effectiveness and cost-benefit analysis. Both analyses represent economic tools for decision makers and politicians, as analyses provide costs of measures or combination of measures on one side as well as implementation of objectives and potential additional benefits on the other side.

The above mentioned analyses were also applied in the process of setting the programme of hydromorphological (hereinafter called HM) measures in Slovenia. In the first stage, the generic catalogue of HM measures and selection of suitable measures for specific HM altered water body were prepared. In the later stage, the costs and effects of measures were compared. As a case study for cost-effectiveness analysis, the Polskava River, a tributary to the Drava River in the Danube River Basin District, was chosen. In general the whole Drava River Basin is denoted with significant HM pressures that are consequence of the driving forces agriculture, urbanization and hydro power utilisation. In the '70s, intensive agricultural land use was in development, thus extensive drainage systems were built and rivers were straighten and re-profiled. In addition, urbanization along rivers spread rapidly and consequently the flood protection was decreased. Many rivers have undergone progressive changes away from their natural state – the most evident are meander cut-offs, regular profile and planform and lack of vegetation buffer zone.

Knowing the reference HM state of the Polskava River, three different combinations of measures for HM status improvement were defined. The first two are comparable regarding to achieving the same goal – one combination is about removing hard structures, increasing of adjacent floodplain zone and setting self-maintaining conditions and the other one is about setting different engineering-biological measures within existing river profile. The third combination with minor effectiveness is about inserting sample blocks that contribute to more heterogeneous conditions in stream channel.

As the result of cost-effectiveness analysis on the Polskava River, the first combination was the most suitable if taking in consideration realistic opportunity cost because of agricultural production forgone.

With analysis recognized, the most cost-effective accession to restoring rivers firstly requires setting of numerous administrative measures that will enable implementation of such restoration measures in Slovenia.

Methodology

Programme of measures for hydromorphological pressures and significant environmental impacts of human activity was prepared as shown on Figure 1. Both of economic analysis (cost-effectiveness and cost-benefit) were taken into consideration, however method and results for cost-effectiveness analysis are presented in detail.

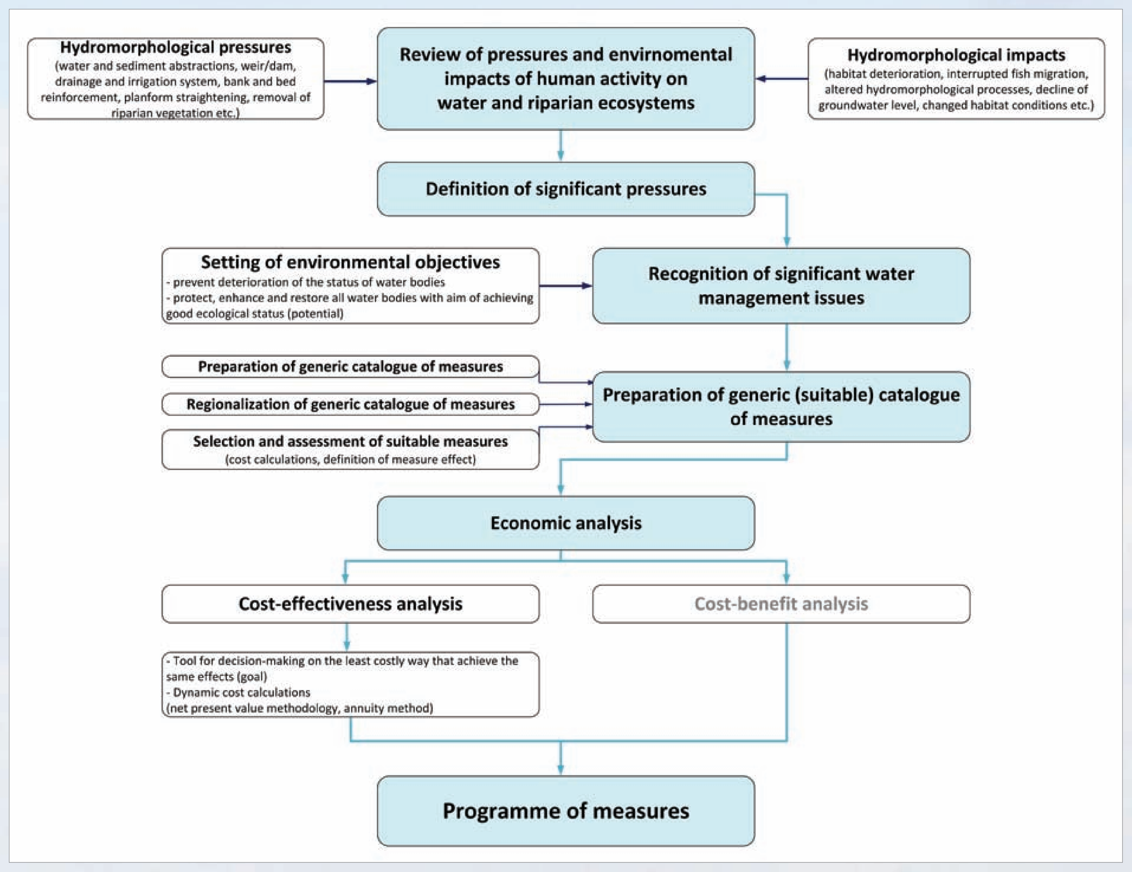

Figure 1: Concept of preparation of programme of measures

Case study area

The Polskava River, a tributary to the Drava River in the Danube River Basin District, has total drainage basin of 189,2 km^2 and total length 30,3 km (Figure 2). Polskava drainage basin is divided into 2 water bodies, the second (lower) water body that has drainage basin area of 150,7 km^2 and length 28,0 km is analyzed in this contribution. Water body is denoted with numerous hydromorphological pressures as: water abstractions for fish farms, weirs and impoundments, high percentage of urbanization and agricultural area (Figure 3), drainage system and rigid engineering works, that changed channel planform, natural cross section and riparian zone (Figure 4-10). Before extensive engineering works the Polskava River was typical meandering river with wide riparian zone and high ecological value.

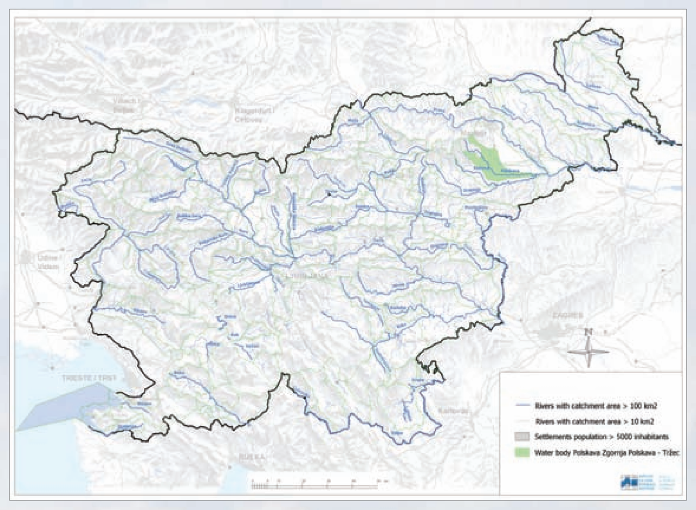
Figure 2: Drainage basin of the Polskava River

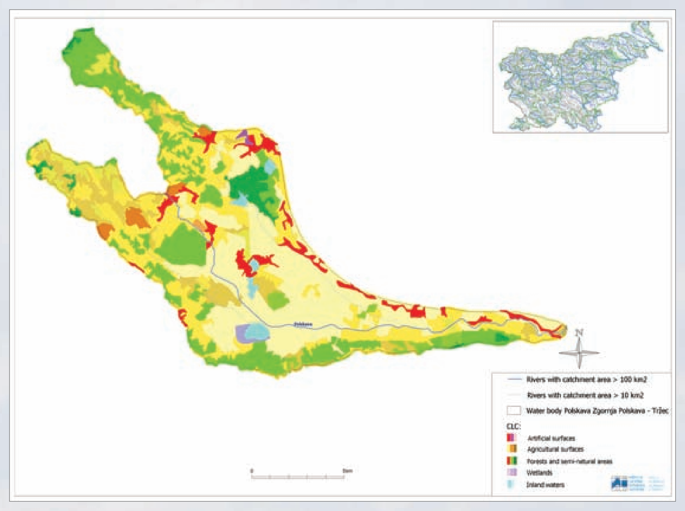
Figure 3: Land use on the Polskava drainage basin (CLC, 2006)

Because of flood protection of settlements in the nearness of the Polskava River also 2 accumulation were built, one of them is partly still under construction. After finishing accumulation construction, flood protection will be assured and regulation of the Polskava River will become disused and obsolete, what is good argument for restoring part of the Polskava River.


Figure 4: Landscape in the Polskava drainage basin


Figure 5: Widely extended agricultural landscape


Figure 6: Intensive agricultural production in riparian zone


Figure 7: Accumulation Medvedce

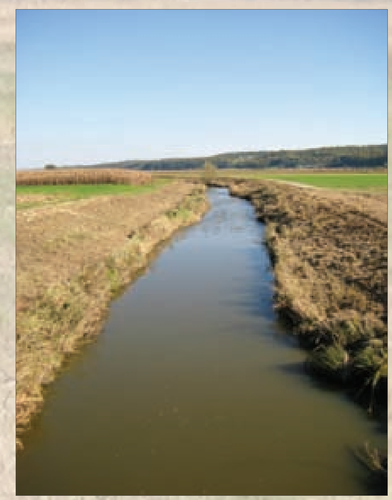
Figure 8: Changed planform and profile

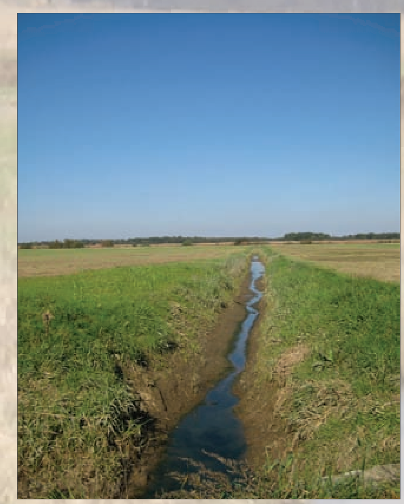
Figure 9: Drainage system


Figure 10: Water abstraction for fish farm

Selection and assessment of appropriate measures

From generic catalogue of hydromorphological measures (Bavarian, Austrian and Slovenian catalogue), appropriate measures for the Polskava River were chosen and compared considering their effect and costs. Three different measure combinations were prepared. Effects were assessed separately for different quality components (Table 1), cost were calculated separately for type of costs (Table 2-4).

Table 1: Appropriate measures and their potential effects on quality elements

APPROPRIATE MEASURES FOR THE POLSKAVA RIVER (selected from generic catalogue of hydromorphological measures)	**Potential effects on quality elements**				
	Fish	Macrozoobenthos	Macrophytes, phytobenthos	Phytoplankton	Chemical quality
Removal of bank reinforcement (lateral walls, hard lateral structures)	+++	+++	+	o	o
Replace drop-off or weir by ramp (enable fish migration)	++	+	o	o	o
Establish natural planform (course of water body)	+++	+++	+	o	o
Redesign water body profile (cross section)	+++	+++	+	o	o
Insertion of massive stone (wooden) blocks (to establish erosion process)	++	++	+	o	o
Insertion of dead timber	++	++	+	o	o
Develop flood plain and riparian zone (vegetation) by succession	++	++	++	++	+
Develop riprarian vegetation by trees and reed planting	++	++	++	++	+
Maintain riparian vegetation close to nature tending	+	++	++	o	o
Activate retention areas	++	+	+	o	o

Table 2: Measure combination A and cost calculation

MEASURE COMBINATION A (dynamic, self-maintaining restoration with minor engineering works; achieved environmental goals)	**Economic costs**				
	Land requirements (000 €)	Other investment costs (000 €)	Operation, maintenance costs (000 €), 4 years	Opportunity costs (000 €), 4 years	Total costs (2012-2015) (000 €)
Replace drop-off or weir by ramp (enable fish migration)	0	120	9,6	0	129,6
Removal of bank reinforcement (lateral walls, hard lateral structures)+land	300	1 080	43,2	24	1 447,2
Develop flood plain and riparian zone by succession	0	0	0	0	0
Develop riparian vegetation by trees and reed planting	0	420	67,2	0	487,2
SUM	300	1 620	120	24	2 064

Table 3: Measure combination B and cost calculation

MEASURE COMBINATION B (Restoration - engineering works; achieved environmental goals)	**Economic costs**				
	Land requirements (000 €)	Other investment costs (000 €)	Operation, maintenance costs (000 €), 4 years	Opportunity costs (000 €), 4 years	Total costs (2012-2015) (000 €)
Replace drop-off or weir by ramp (enable fish migration)	0	120	9,6	0	129,6
Redesign water body profile (cross section)	0	2 400	96	0	2 496
Develop riparian vegetation by trees and reed planting	0	420	67,2	0	487,2
Maintain riparian vegetation close to nature tending	0	60	0	0	60
SUM	0	3 000	172,8	0	3 172,8

Table 4: Measure combination C and cost calculation

MEASURE COMBINATION C (Restoration - engineering works; small possibility of environmental goals achieving)	**Economic costs**				
	Land requirements (000 €)	Other investment costs (000 €)	Operation, maintenance costs (000 €), 4 years	Opportunity costs (000 €), 4 years	Total costs (2012-2015) (000 €)
Replace drop-off or weir by ramp (enable fish migration)	0	120	9,6	0	129,6
Insertion of massive stone (wooden) blocks (erosion process)	0	240	48	0	288
Insertion of dead timber	0	60	24	0	84
Maintain riparian vegetation close to nature tending	0	60	0	0	60
SUM	0	480	81,6	0	561,6

Calculation is prepared for restoration section of the Polskava river, that is 12 km long and is located in the nearness of accumulation Medvedce, in agricultural landscape. Within land requirements it is supposed that additional 5 m zone is needed for self-maintaining restoration, alternately on each side along section. Costs for needed 60 000 m^2 amount to 300 000 € (price of 1 m^2 is 5 €). Costs for other measures were taken from Bavarian catalogue of measures, where also percentage of investment costs is expressed as operation and maintenance costs. Opportunity costs were estimated as loss in agricultural production, that is estimated on 1 000 €/ha/year. For comparison of three measure combinations operation, maintenance and opportunity costs were calculated for time period 2012-2015 (4 years).

Results and discussion

Differences between investment costs, operational, maintenance costs and opportunity costs, that are assumed for time period 2012 (all the measures should be made operational) till 2015 (achieved environmental objectives) are shown on Figure 11 for all the three measure combinations. Measure combination B requires the highest costs, despite zero opportunity costs (that are part of measure combination A).

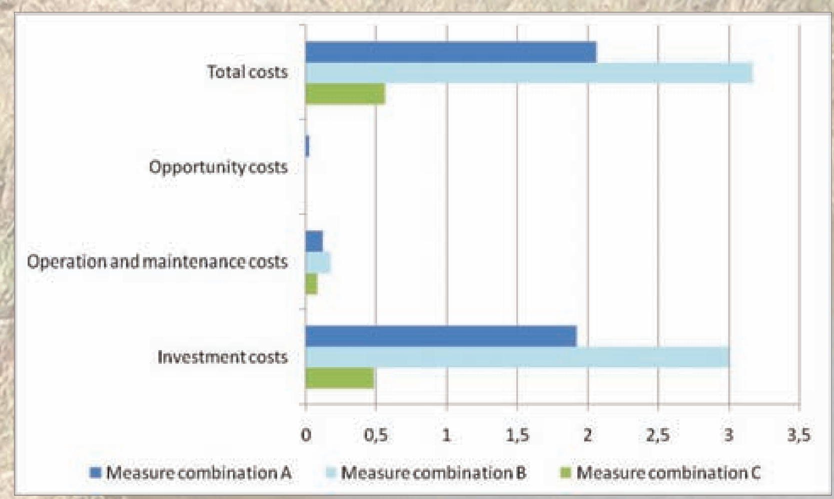

Figure 11: Costs comparison for measure combinations (time period 2012-2015)

Calculation of Net Present Value for different measure combinations

The least costs solution was identified in an analysis of financial economics with net present value method. Net present value (hereinafter called: NPV) is the standard method for the financial appraisal of long-term projects. Costs and benefits often occur in the future. The time preference is incorporated into CBA through the application of discounting future costs and benefits and through accumulating costs and benefits that occurred in the past. This allows referring costs and benefits to a common point in time. If the present is chosen as the reference point in time, this process allows determining the net present value.

Therefore the year 2015 was selected for the dynamic methods as a reference year. To compare the measure alternatives with each other (combination A, B and C), a uniform project time period must be fixed. As a rule, the examination time period extends until the "life time" of the measures. Examination time period for the measures regarding river restoration in our case was 50 years (Table 5).

Table 5: Calculation of Net Present Value for measure combination A, without opportunity costs

MEASURE COMBINATION A		**I. Planning phase**			**II. Construction phase**	**III. Mainteinance phase**				
		Planning costs			Investment costs	Operational and mainteinance costs				
	Year	2009	2010	2011	2012	2013	2014	2015		2065
	Period	6	5	4	3	2	1	0		50
Annual cash flows		-54.000	-54.000	-54.000	-1.758.000	-30.000	-30.000	-30.000	... NPV after 50 years ...	-30.000
Inflation rate	1,00 %	1,062	1,052	1,041	1,030	1,020	1,010	1,000		1,645
Annual cash flows inclusive inflation rate	6	-57.332	-56.755	-56.193	-1.811.269	-30.603	-30.300	-30.000		-49.339
Interest rate	3,00 %	1,194	1,159	1,126	1,093	1,020	1,030	1,000		4,384
Present value (reference year 2015)	-3.147.019	-64.479	-62.601	-60.777	-1.921.014	-30.603	-30.900	-30.000		-11.255
Present value total		-64.479	-127.080	-187.857	-2.108.871	-2.139.474	-2.170.374	-2.200.374		-3.147.019

All costs (planning costs, investment costs, operational and maintenance costs, opportunity costs) are related to a chosen reference year-2015. The inflation rate was set at 1% (set to simplify calculation) and used for the accumulation of costs in the past (costs, which occurred before the reference year) to determine their value in the future. As a discounting factor, an interest rate set at 3% (LAWA guidelines for long-term interest rate) was used for the discounting the costs (costs, which occurred after the reference year). Planning costs were calculated as 10% of investment costs. For measure combination A two different calculations were made - with and without considering opportunity costs.

Table 5: Calculation of Net Present Value for measure combination B

MEASURE COMBINATION B		**I. Planning phase**			**II. Construction phase**	**III. Mainteinance phase**				
		Planning costs			Investment costs	Operational and mainteinance costs				
	Year	2009	2010	2011	2012	2013	2014	2015		2065
	Period	6	5	4	3	2	1	0		50
Annual cash flows		-100.000	-100.000	-100.000	-2.700.000	-43.200	-43.200	-43.200	... NPV after 50 years ...	-43.200
Inflation rate	1,00 %	1,062	1,051	1,041	1,030	1,020	1,010	1,000		1,645
Annual cash flows inclusive inflation rate	6	-106.152	-105.101	-104.060	-2.781.813	-44.068	-43.632	-43.200		-71.048
Interest rate	3,00 %	1,194	1,159	1,126	1,093	1,061	1,030	1,000		4,384
Present value (reference year 2015)	-4.903.536	-126.751	-121.841	-117.121	-3.039.762	-46.752	-44.941	-43.200		-16.207
Present value total		-126.751	-248.592	-365.713	-3.405.475	-3.452.227	-3.497.168	-3.540.368		-4.903.536

Comparison of Net Present Value for different measure combinations

Figures 12-14 show the comparison of possible measure combinations in order to achieve good ecological status. With NPV method, the combination C was identified as the most cost effective solution, but it is questionable if the environmental objectives can be achieved. For measure combinations A and B it is assumed that environmental objectives will be achieved, so comparison is more appropriate. It is visible, that measure combination A is in both cases (considering or not opportunity costs) more cost-effective than measure combination B.

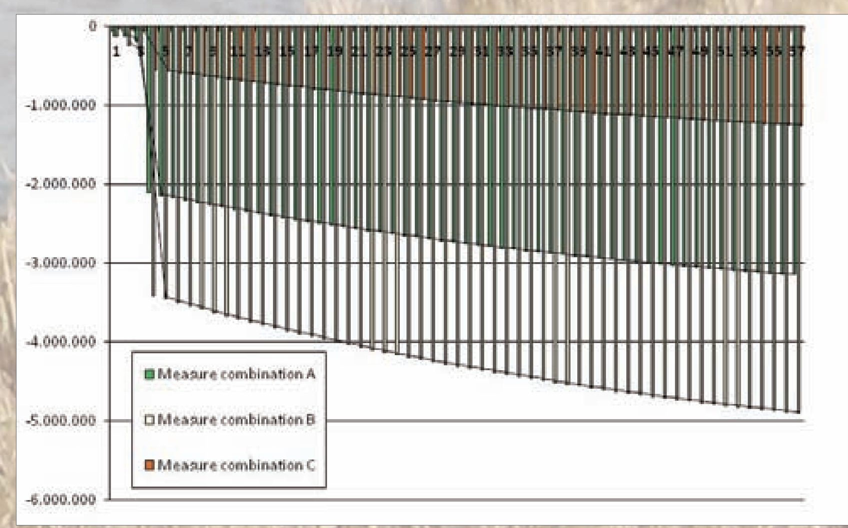

Figure 12: Comparison of NPV (without opportunity costs)

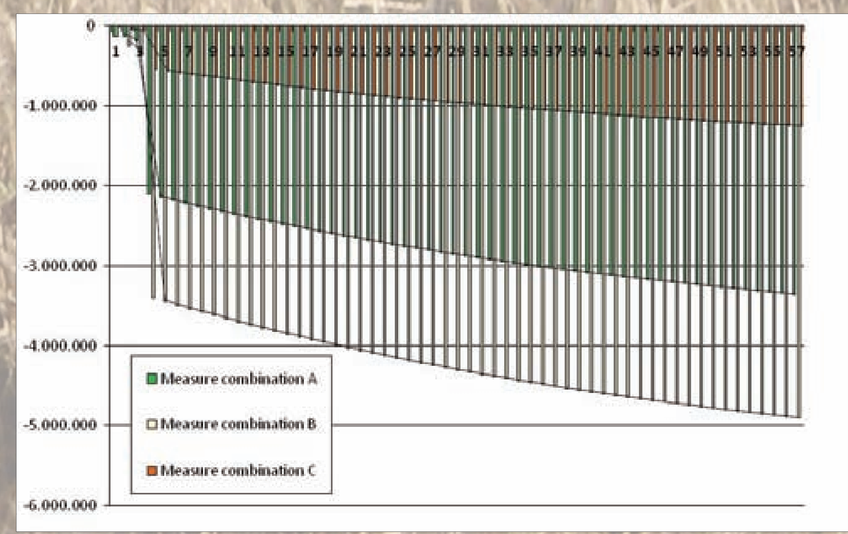

Figure 13: Comparison of NPV (with opportunity costs)

Taking into consideration unrealistically high opportunity costs for measure combination (10.000 €/ha) the measure combination B would become more cost-effective than combination A.

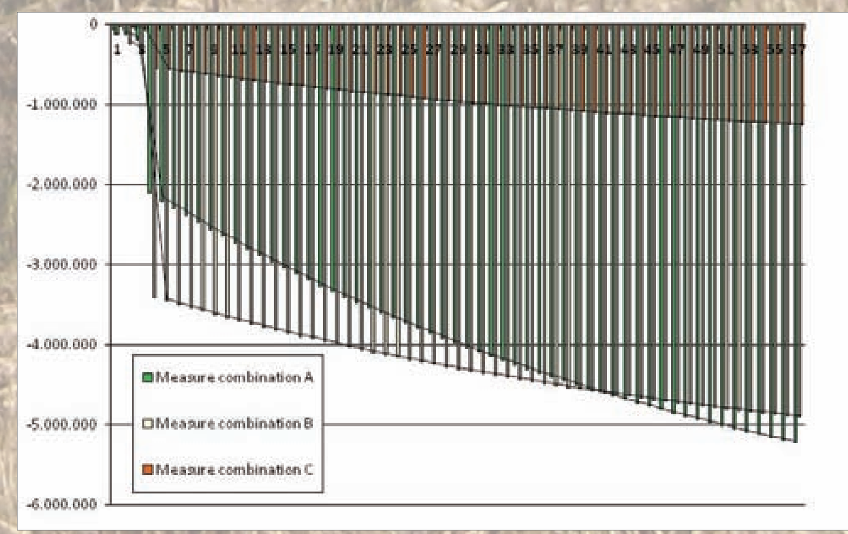

Figure 14: Comparison of NPV (with unrealisticlly high opportunity costs in combination A)

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